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# ENVIRONMENTAL PROTECTION AGENCY

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# MUNICIPAL SLUDGE MANAGEMENT

## Environmental Factors

## ENVIRONMENTAL PROTECTION AGENCY

[FRL 552-7]

### MUNICIPAL SLUDGE MANAGEMENT

#### Environmental Factors; Technical Bulletin

This Technical Bulletin has been prepared to assist Environmental Protection Agency (EPA) Regional Administrators in evaluating grant applications for construction of publicly owned treatment works under section 203(a) of the Federal Water Pollution Control Act as amended. It also provides designers and municipal engineers with information for selecting a sludge management option.

The bulletin was developed by an Agency workgroup with substantial assistance provided by individuals from the Council on Environmental Quality, the U.S. Department of Agriculture, the Food and Drug Administration, and the Department of the Army.

The bulletin addresses only factors important to the environmental acceptability of a particular sludge management option. The environmental assessment/environmental impact statement procedure is used to determine the acceptability at a specific site. This procedure is described in EPA's regulation for "Preparation of Environmental Impact Statements" (40 FR 6, Appendix I).

Another aspect of sludge management which is of great importance is the cost-effectiveness of a proposed sludge management option. Information on the EPA cost-effectiveness program is contained in Appendix A.

The requirements of the Act for higher levels of wastewater treatment will result in a substantial increase in the quantity of sludge produced at publicly owned treatment works. Disposition of these sludges is not simple. Methods used in the past are now restricted by specific laws or regulations, or are subject to other constraints in view of new information of environmental significance.

EPA, continuing the work of its predecessor agencies, has been developing environmentally acceptable methods for the management of municipal sludge since the enactment of the first Federal water pollution control laws. The initial phases of the research program were concerned with the characteristics and dewatering properties of primary and secondary sludge because of the need to dewater sludge before its ultimate disposal. The current program emphasis has shifted toward development of improved technology for returning the sludges to the environment in an ecologically acceptable manner. Also, the Agency is requiring new measures, such as source control and pretreatment which should reduce the heavy metals problem associated with sewage sludges.

The Agency has been aware of the growing sludge disposal problem and the need to verify and expand the technology that is now being utilized. For example, a long-term land application project has been directed at determining the beneficial uses of sludge for strip mine reclamation and for soil enrichment in crop production. These studies have carefully monitored the heavy metals uptake in various forage and grain crops.

A large increase in the amount of sludge generated has occurred with the use of chemical precipitants for nutrient control and the upgrading of secondary treatment facilities. The Agency has been active developing new technology for solving the problem, including recovery and reuse of the chemical additives.

EPA will continue its comprehensive research program for municipal wastewater sludge processing, utilization and disposal. This program will concentrate on demonstration of new technologies which will recycle or reuse sludges, or recover residuals contained in sludges.

For example, new technologies are being examined to determine if there are cost-effective methods for producing or recovering marketable products in the processing of sludge. These products may include: metals recovery, simple organic acids, fertilizer bases, soil conditioners, methane, and the recovery of process heat.

Health effects research will include investigation into land application, disinfection, and composting. The health effects of airborne contaminants from incineration and the improved technology for reducing or eliminating pollutant emissions will be evaluated. It is also EPA's intent to continue cooperative agreements with other local, State and Federal agencies.

The Technical Bulletin is based on current knowledge. It will be modified from time to time as additional information becomes available from current and future research, development, and demonstration projects as outlined above. New research, development, and demonstration projects which offer potential for reducing costs or improving technology are encouraged; this includes projects that do not meet the specific criteria of the bulletin, if there is reason to believe that they will eventually be acceptable.

During the development of this Technical Bulletin, considerable disagreement surfaced on the topic of utilizing sewage sludges by application to agricultural lands. Although utilization of sewage sludges as a resource to recover nutrients and other benefits has been encouraged by PL 92-500 and the EPA Science Advisory Board, the workgroup members and others involved in developing this Technical Bulletin have received conflicting opinions concerning the overall merits vs hazards of applying sludges to cropland. Possible adverse effects upon the human food chain (e.g., potential for increasing human cadmium intake) has remained a major concern expressed whenever this practice is considered. The relative risks of applying sewage sludges to croplands, when compared to other routes through which these contaminants enter the human diet, have yet to be determined.

Because of the wide interest in this subject, EPA is soliciting comments on the proposed bulletin. In particular, views and data are solicited on publicly acceptable sludge management alternatives, the occurrence of heavy metals in sludge, the control of these contaminants in the agricultural use of sludge to grow foods, and related impacts upon the human food chain. This bulletin places primary reliance on the Food and Drug Administration and the U.S. Department of Agriculture to establish recommendations for acceptable levels of heavy metals in food crops and best agricultural practices for sludge application to agricultural lands.

Interested persons should submit written comments, views, or data to the Director, Municipal Construction Division (WH-547), Office of Water Program Operations, Environmental Protection Agency, Washington, D.C. 20460. All such communications received prior to 90 days from publication of the proposed technical bulletin in the FEDERAL REGISTER will be considered in developing the final Technical Bulletin. If the degree of public interest in the utilization of sewage sludge expressed during the public comment period indicates a major concern, public hearings will be held prior to publishing the final document.

Dated: May 18, 1976.

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TECHNICAL BULLETIN

MUNICIPAL SLUDGE MANAGEMENT: ENVIRONMENTAL FACTORS

*Proposed for Public Comment*

This document is a preliminary draft. It has not been formally released by EPA and should not at this stage be construed to represent Agency policy. It is being circulated for comment on its technical accuracy and policy implications.

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APPENDICES

Appendix I[1] "Preparation of Environmental Impact Statements" 40 CFR 6.

Appendix II Groundwater Extract from "Alternative Waste Management Techniques for Best Practicable Waste Treatment" EPA–40/9–75–013, October 1975.

Appendix III Guidelines for the Land Disposal of Solid Wastes 40 CFR 241.

Appendix IV "New Source Performance Standards for New Stationary Sources; Subpart O—Standards of Performance for Sewage Treatment Plants, 40 CFR 60.15.

Appendix V "National Emissions Standards for Hazardous Air Pollutants;" Subpart E—National Emission Standard for Mercury, 40 CFR 61.5.

Appendix VI Subchapter H—Ocean Dumping, 40 CFR 220–227.

CHAPTER I

*Introduction*

1–1. The treatment of wastewaters for pollutant removal produces not only relatively clean water for discharge, but also a significant quantity of residue material. For domestic sewage, treated in publicly owned plants, this residue is essentially organic in nature, although measurable quantities of metal, minerals, and other compounds are also invariably present. Where industrial wastewaters are treated together with domestic sewage, the potential for additional foreign materials in the resulting sludge is increased. Further, pathogenic organisms in sewage may survive the wastewater treatment process and remain in the residue.

1–2. Depending upon the composition of the wastewater treatment plant sludge, the quantity involved, and the disposal method, disposal of this residue material can have a significant impact on the environment. It is essential for wastewater treatment installations to consider the proper disposal of sludge produced as well as the proper disposal of treated wastewater.

The requirements of the Federal Water Pollution Control Act, as amended, emphasize the need for environmentally sound means for sludge disposal. The national requirement for secondary treatment, for example, will not only result in production of a greater quantity of sludge than before, but will also result in greater quantities nationwide, and possibly more concentrated forms of contaminants present in the sludge.

1–3. The disposition of wastewater treatment plant sludges is a complex problem. It can affect simultaneously air, land, and water, and encompass such varied considerations as human health, animal health, plant growth, and protection of ground and surface water from pollution. EPA Regional Administrators consider these matters as they evaluate sludge disposal systems included in the design of publicly-owned treatment works for which construction grant applications are made. Despite the still limited information available on the complex issue of sludge utilization and disposal, the need for definition of a baseline of acceptable sludge utilization or disposal practice remains.

1–4. For the reasons cited above, a clear statement of acceptable methods for sludge utilization or disposal is presented in this document. This technical bulletin provides guidance on the factors to be considered in the environmental assessment and on general agency policy to be used in reviewing the facts of a particular situation. The methods listed are based upon current knowledge. No attempt is made to imply that the listed methods are optimum for sludge utilization or disposal, but rather to state that adverse environmental factors associated with each method may be tolerable under certain site conditions. The determination of acceptability is based on the environmental assessment and, if necessary, the environmental impact statement for a specific project.

1–5 The bulletin is divided into two distinct parts. The first part includes methods in which the sludge is utilized as a resource. The second part includes those methods in which the sludge is not utilized for any beneficial purpose.

1–6. Methods which appear to have great promise, but which have not been used in existing facilities, are not included in this list. As these developing methods are demonstrated in practical use, and as supporting information is obtained, they will be added to the list of acceptable methods. Because it is the policy of EPA to encourage and, where possible, assist in the development of new or advanced wastewater treatment procedures, Federal grant funds may be awarded for the construction of sludge utilization or disposal facilities not in the bulletin, provided sufficient information is presented by the grant applicant to determine that these facilities would meet applicable statutory and regulatory requirements and would be environmentally acceptable.

1–7. Proper operation, maintenance, and monitoring of sludge utilization or disposal practices are essential to ensure that adverse environmental effects do not result. Grant applicants must demonstrate that they will have managers, operators, and resources necessary to achieve and maintain the required performance on a continuing basis.

CHAPTER II

*Sludge Utilization Methods*

2–1. *General.* Because land application of sludge conserves organic matter, nitrogen, phosphorus, and certain essential trace elements, such utilization is encouraged when it is supported by environmental assessment and, if necessary, an environmental impact statement.

Specifically, stabilization of sludge and subsequent land application for enhancement of parks and forests and reclamation of poor or damaged terrain should be considered for the utilization of sludge. Application of stabilized sludge to agricultural lands on which crops entering the human food chain will not be grown may also be regarded as an environmental acceptable method of slude disposal. However, application of sludge to lands on which crops entering the human food chain will or may be grown must be examined closely in terms of protection of human health and future land productivity. Priority consideration should be given to non-agricultural uses.

2–2. *Information for Project Evaluation.*

2–2.1 *Sludge Characteristics.* Sludge from existing plants should be tested to determine nutrient values, heavy metals, and other constitutents which may be economically recycled or cause environmental damage. The specific tests and test schedule should be based on regulatory requirements, this bulletin, the intended use of the sludge, and contaminants likely to be present. For new projects, it will be necessary to estimate the sludge characteristics. Some indication may be available from pilot plant studies, but such studies are rarely conducted at smaller plants.

Where sludges are to be applied to agricultural land, industrial users of municipal wastewater treatment works should be required to pretreat their wastewaters to minimize the presence of heavy metals and other sludge contaminants from industrial sources. Pretreatment may be required beyond the Federal pretreatment standards in 40 CFR 128. (See Federal Guidelines: Pretreatment of Pollutants Introduced into Publicly Owned Treatment Works.) However, quantities of these materials also may be present in wastewaters usually considered of non-industrial origin.

In developing pretreatment programs, special attention must be given to the disposal of sludges created or materials removed during the pretreatment process. Disposal of these materials must be in an environmentally sound manner.

2–2.2 *Site Soils.* For use of sludge on agricultural land, the soils should be tested for cation exchange capacity, pH, and background heavy metals. These tests can be arranged through the Agricultural Extension Service or other laboratories. The number and extent of these tests may be reduced or waived for largely domestic sludges where the application rates are low (paragraphs 2–3.10 and 2–4), or where the tests are not significant to a specific project (such as application to non-agricultural lands), or where adequate soil survey information already exists.

2–2.3 *Ground Water.* A review of existing information and/or an investigation of soil and ground water conditions should be made for sites where sludge is to be applied to the land. The extent of the evaluation should be based on the size of the project and the relation to ground water. Maintaining the pH of the combined soil and sludge above 6.5 will prevent solubilization and migration of most metal ions.

2–3 *General Requirements for Land Application of Sludges*

2–3.1 *Stabilization.* Before land application, sludge must be stabilized to reduce public health hazards and to prevent nuisance odor conditions. The stabilization method most frequently used is anaerobic digestion, but there are numerous other acceptable methods.

Experience shows that consistent and effective control of odors is a major factor in the acceptability of land application. The odor conditions are closely related to anaerobic bacterial action on volatile organic matter in both the liquid and solid portions of the sludge. Either a high degree of reduction of volatile matter, or chemical treatment to inhibit bacterial action, is necessary to prevent nuisance odors.

The degree of volatile matter reduction achieved by an aerobic digestion may vary greatly, depending on the basic digestor design and the percentage of volatile solids in the raw sludge. Well designed and carefully operated high rate anaerobic digestors can sufficiently digest sludge to control odors and pathogens when the sludge is digested for 10 days at 95 degrees F. High rate digestion requires close operational control for

[1] Appendices I and III through VI filed as part of the original document.

successful performance. Smaller plants should use standard rate digestion. Although these conditions can reduce the number of influent fecal coliforms by 97 percent or more, the remaining levels of pathogens can still be significant to public health.

Other methods to prepare sludge for land application, such as aerobic digestion, chemical treatment (lime treatment, etc.), heat stabilization, or heat drying, also may be used, if the grant applicant can show, for the specific case, that the public health factors and nuisance potential are no greater than would be associated with anaerobic digestion.

Chemical treatment typically does not significantly reduce volatile matter but the rate of decomposition is slowed so that any odors are dissipated at very low concentrations. Odor conditions may occur in time if the rate of anaerobic decomposition increases, such as by neutralization of the chemical treatment. In this case the sludge should be incorporated into the soil (paragraph 2–3.7).

At some plants, the stabilized sludge is spread on drying beds or temporarily stored in sludge lagoons. These methods decrease potential odor problems from sludge applied to land since additional stabilization occurs with time. Caution must be exercised, however, to ensure there are no objectionable odors from the storage site.

Digested sludge can also be further stabilized by various composting systems.

2–3.2 *Additional Pathogen Reduction.* For some projects it may be necessary to achieve additional pathogen reduction beyond that attained by stabilization. Any one of the following methods has been reported to be successful:

a. Pasteurization for 30 minutes at 70° C.

b. High pH treatment, typically with lime, at a pH greater than 12 for 3 hours.

c. Long term storage of liquid digested sludge for 60 days at 20° C of 120 days at 4° C.

d. Complete compositing at temperatures above 55° C as a result of oxidative bacterial action and curing in a stockpile for at least 30 days.

2–3.3 *Crops Suitable for Sludge Application.* Crops vary widely in their reaction to sludge enriched soils. Some crop species may be adversely affected by trace heavy metals in the sludge. Additionally, the crop may take up and accumulate certain of these trace elements, thereby inhibiting future use of the harvested materials, particularly in the human food chain. The reaction of a specific crop to sludge application is extremely site dependent. Factors such as soil type, pH, moisture content, climate, and crop species are important. For advice concerning crops which can be satisfactorily grown in sludge enriched soils, consult USDA and State Agricultural Experiment Stations.

Forest sites offer special opportunities for beneficial use of sludge to improve soil fertility and increase plant growth. With many tree species, nutrient uptake apparently is small compared to that of certain agronomic crops; however, in the case of certain tree species, involving intensive cultural operations for quick growth and high production of wood fiber, rapid uptake of nutrients is obtained. Heavy applications of liquid digested sludge in forests (in excess of 15 dry tons of sludge per acre per year) might, under special circumstances, necessitate either pre-removal (reduction) of nitrogenous sludge substances or periodic on-site anaerobic reduction treatments, to prevent excess nitrate pollution of groundwaters.

2–3.4 *Public access* must be controlled by either positive barriers, such as fences, or by remoteness of the site. Where this is not done, the number of pathogens in the sludge should be reduced (paragraph 2–3.2).

2–3.5 *Groundwater Protection.* Projects for land application of sludges will be designed so that the permanent groundwaters (groundwater which is not removed from the ground by an under-drain system or other mechanical means) in the zone of saturation (where the water is not held in the ground by capillary tension) will be protected from pollution. Consideration should be given to the extent of the project, the quality of the groundwaters, and the fact that groundwater is typically used for drinking water supply with little or no additional treatment. Also, in some areas, groundwater recharge of surface streams may be significant. Specific groundwater criteria for land application systems are contained in the EPA publication, "Alternative Waste Management Techniques for Best Practicable Waste Treatment" (EPA–40/9–75–013, Appendix II).

2–3.6 *Controlling Surface Water Runoff.* Surface water runoff must be controlled to prevent violation of water quality standards which might result from the migration of sludge contaminants into receiving bodies of water. Containment and controlled release of runoff from sludge application areas, or effective erosion control methods, must be practiced as necessary. Consideration must also be given to dissolved materials which may leach out of the sludge into surface runoff.

2–3.7 *Sludge Application Methods.* Liquid digested sludge may be applied to the land by using various methods, such as a tank truck, plow injection, or ridge and furrow spreading. Stabilized sludge, or composted material from digested sludge, may also be spread upon the land. If desired, the sludge can be incorporated into the soil by plowing, discing, or other similar methods. The use of incorporation and injection methods is encouraged as a means of improving public acceptance of sludge application by decreasing possible odor generation and unsightly deposits on crops.

Spray application of digested sludge to the land is acceptable when the transport of aerosols beyond the boundaries of the application area is minimized. The use of low pressure sprays, short risers, or remoteness of application sites is suggested. When spraying at low pressures, the sludge should be screened to prevent nozzle plugging.

2–3.8 *Application Rates.* The sludge application rate per acre must be managed to ensure that environmental requirements are met. It is not possible to give a rate, or even an upper limit, which would be universally applicable, since the limit varies widely and must be determined for each site. Application rates can be estimated based on experience, site exploration data, or test plot data.

Nitrogenous substances usually limit annual application rates. The rate of sludge application to agricultural land must be consistent with the use of nitrogen by agronomic crops to prevent nitrate pollution of groundwater. The information required to establish a sludge application rate includes: (1) total and inorganic nitrogen content of sludge; (2) nitrogen, phosphorous, and potassium requirement of crop grown; and (3) soil test for available phosphorous and potassium. Supplemental fertilizer, especially potassium, may be needed to optimize crop production. As a guide, sludge application rates should be such that the total amount of plant available nitrogen added is no greater than twice the nitrogen requirement of the crop grown. Plant available nitrogen includes that mineralized from the soil and the inorganic sludge nitrogen (ammonium and nitrate), plus a mineralization rate of 15 to 20 percent of the sludge organic nitrogen for the first growing season, and 3 percent of the residual sludge nitrogen for three subsequent growing seasons. Volatilization of ammonia from surface applied sludge should be taken into account; experience has shown that about 50 percent of this nitrogen may be lost if the material is not immediately incorporated. USDA and State Agricultural Experiment Stations should be contacted to obtain plant nitrogen, phosphorous and potassium requirements and soil test information. Site monitoring should be the responsibility of the municipality.

It is possible that the presence in the sludge of certain salts, phosphorous compounds, metals, radionucleides and other materials may also limit application rates in specific instances.

Each prospective land application site should be assessed on an individual basis, with consideration given to both sludge characteristics and soil characteristics.

Sludge is generated relatively constantly throughout the year. The application rate must be harmonized with the crop growing season. A mass balance is necessary to determine the amount of sludge storage required during intervals when the sludge is not applied to the land.

2–3.9 *System Operation.* The grant applicant must show the capability to manage and operate the system. Operational aspects to be described in the operation and maintenance manual include the monitoring plan, review of monitoring data, action to be taken when monitoring indicates a problem, and sources of additional expert guidance.

2–3.10 *Monitoring.* The grant applicant must develop and implement a plan for adequate monitoring of each land application site where the application rate will exceed 10 dry tons/acre/year for liquid digested sludge, or 50 dry tons/acre over a three year period for dried or dewatered sludge. Use of bagged-sludge fertilizer products for the retail market will not require site monitoring. However, producers of bagged-sludge fertilizer products are encouraged to incorporate pathogen destruction in their sludge conditioning processes and to avoid higher level heavy metals content sludges for this purpose.

The site monitoring plan must be specifically designed for applicable local conditions, and is to include consideration of heavy metals, persistent organics, pathogens, and nitrates in groundwater, surface water, sludge, and soils.

The size of the project and nature of the lands to which sludge is being applied is important. For new projects, it will be necessary to estimate the sludge characteristics and crop response. Where required, monitoring should be more frequent, at least initially, until successful performance is assured.

2–3.11 *Surveillance of Operation and Monitoring.* The operation and monitoring data of the system must be periodically reviewed to ensure satisfactory performance. Where there is not a local or state program for this purpose, an alternative independent review will be necessary. This could be done by a consultant or by an agricultural extension service. The grant application should show the arrangements made for surveillance.

Operational and monitoring data must be available to authorized EPA representatives on request.

2–4. *Additional Requirements for Sludge Application to Agricultural Lands.* In addition to the foregoing general requirements, the application of sludge to agricultural lands which may be used to grow crops must be accomplished so as to ensure cropland resources are protected and harmful contaminants are not accumulated in the human food chain. Review of projects which include application of sludge to agricultural lands must be based on informed judgment and fully consider the conditions specific to a given site.

2–4.1 *Projects of Minimal Concern.* Some projects are clearly of minimal concern either because of their relative size and impact or because they are controlled by other means. An environmental assessment involving testing of the sludge for heavy metals and pathogens will verify this is the case for the particular project. In these cases of lesser concern, the project should conform with the foregoing general requirements, but need not necessarily conform with each of the specific limits and monitoring requirements. Examples of this type of project include:

a. Where the design flow of the publicly owned treatment works is less than one million gallons per day. This is particularly the case where there are no industrial users of the system and the application rates are low.

b. Where the sludge is applied to publicly owned or leased land dedicated to receive sludge. Controls should be imposed to ensure there is no misuse of this land. Where the land has received unusually high amounts of metals, FDA clearance should be obtained before using crops from such land in the human food chain.

c. Where the existing sludge operation is a commercial activity, producing bagged products. In this case, there should be a temporary variance for non-conforming sludges with an acceptable schedule established to conform with applicable requirements such as metals and pathogens. New projects should not be exempted.

d. For larger projects, or those not otherwise controlled, consideration must be given to the extent of additional resources available for control and monitoring. Some demonstration projects have the capability, including in-house effort and expert assistance, to intensively monitor and evaluate the project as it develops. These work closely with EPA, USDA and FDA, as well as State authorities, to ensure satisfactory results. In effect, the criteria for these demonstration projects are subject to continuing modification as information is developed. For these demonstration projects, the grant review should include the availability of resources for evaluating project performance, the management arrangements for surveillance of the project, and review by other interested agencies such as FDA and USDA.

2–4.2 *Protection of Food Products and Agricultural Lands.* Regulations exist to control the level of mercury and persistent organic chemicals, such as pesticides and polychlorinated biphenyls (PCB's), in certain components of the food chain. However, similar guidelines have not been established for all trace elements in foods. When standards are implemented, those sludge applications involving crops in the human food chain will have to be adjusted to conform. Cadmium and lead are of particular concern in municipal sludge and in some crops grown in sludge-treated soil, as well as mercury, arsenic, selenium, and persistent organics such as pesticides and PCB's.

Because of the wide variety of conditions that can affect the level of heavy metals that may be toxic to plants or taken up by the crop and eventually consumed by humans as part of their diet, absolute numerical limitations are not appropriate. It is recommended that the project conform to any limitations established by FDA or USDA. Where a sludge relatively high in heavy metals content is used, the following measures are prudent:

Reduce heavy metals contamination in the sludge by pretreatment of wastewaters from industrial users;

Maintain a high pH (above 6.5) in the combined sludge and soil;

Concentrate on growing grain crops as opposed to leafy vegetables;

Intensify monitoring of heavy metals in the sludge, soil, and plant tissues.

Even though stabilization methods are used, additional precautions should be taken when sludge is used for agricultural purposes (paragraph 2–3.2). Under certain conditions, specific organisms may survive in the soil for extended periods. Consequently, sludge-treated land should not be used for growing human food crops to be eaten raw until three years after sludge application. For orchard crops eaten raw, heat dried sludge can be used provided the project is approved by the Food and Drug Administration.

Application methods are encouraged that have been demonstrated to prevent direct contact of the sludge and the crop to be consumed. Where such methods are not employed, sludge shall be negative for *Salmonella* and *Ascaris* ova if applied to crops normally cooked in the home before consumption, but marketed without being subjected to a process which is lethal to pathogenic microorganisms and parasites. This also applies to sludge use on dairy pastures. Forage and pasture crops should not be consumed by animals while these crops are physically contaminated by sludge. Grazing animals should not be permitted on pastures before thorough removal of sludge, by rain or some similar method. Where there is a risk of direct ingestion of the sludge by grazing animals, the lead content of the sludge should not exceed 1,000 mg/kg dry sludge and the cadmium content should not exceed 20 mg/kg dry sludge.

2–4.3 *Use of Other Sludges.* The criteria in the preceding subparagraphs are based on limited information and are conservative in defining sludge acceptable for land application. Other sludges may also be acceptable, including some which do not in every respect fall within the above criteria. These sludges should only be used under certain carefully defined and controlled conditions. Regional Administrators should work closely with grant applications desiring to use these sludges in land application projects. Technical assistance to resolve specific questions is available from EPA Headquarters and from the EPA National Environmental Research Centers, especially the Advanced Waste Treatment Research Laboratory. Technical assistance is also available from the Food and Drug Administration and USDA and State Agricultural Experiment Stations.

2–4.4 *Project Review.* When the project includes sludge application to agricultural lands, the facility plan should be reviewed by the U.S. Department of Agriculture and, where crops in the human food chain are involved, by the Food and Drug Administration. This review is particularly important for larger projects, high sludge application rates (paragraph 2–3.10), and where the sludge contains higher amounts of contaminants (paragraph 2–4.2).

2–4.5 *Monitoring Requirements.* Products in the human food chain grown on sludge amended soil should be monitored for heavy metals (cadmium, lead, arsenic, selenium, zinc, copper, nickel, and mercury), persistent organics (chlorinated pesticides, PCB's, etc.), and pathogens (paragraph 2–4.2). At this time it appears that *Salmonella* and *Ascaris* ova would be the pathogens of choice for a monitoring program. The monitoring program (paragraph 2–3.10) should be expanded to include this testing when human food products grown are subject to contact with the applied sludge. These requirements should apply for any project with an application rate greater than 10 dry tons sludge per acre.

## CHAPTER III
## *Sludge Disposal Methods*

3–1. *Sanitary Landfill.*

3–1.1 *General.* Sanitary landfill of sludge, either separately or along with municipal solid waste, is acceptable when supported by the environmental assessment and, if necessary, an environmental impact statement.

3–1.2 *Landfill Procedures.* A sanitary landfill accepting sludge must be designed and operated in accordance with EPA Guidelines for Land Disposal of Solid Wastes (40 CFR 241 Appendix III). While it is recognized that the guidelines were developed for solid waste at Federal facilities, operation of a sanitary landfill accepting sludge should be consistent with the requirements and recommendations contained in the guidelines.

3–1.3 *Odor Control.* The sanitary landfill must be operated so as to prevent nuisance odors. Normally, the sludge must be stabilized as described for land application (paragraph 2–3.1).

3–1.4 *Precautions for Protection of Public Health.* Sludge stabilization and the daily soil cover are generally adequate protection from direct health hazards. Additional precautions may be necessary if the public has unrestricted access to the landfill site.

3–1.5 *Groundwater Protection.* The groundwater underlying the sanitary landfill accepting sludge must be protected against degradation, and the sanitary landfill must meet the groundwater protection requirements (paragraph 2–3.5).

3–1.6 *Operation.* If a sanitary landfill accepting sludge is not operated by the wastewater treatment authority, a written contract or binding agreement is required between the wastewater treatment authority and the operator of the sanitary landfill. Such a binding agreement will include necessary assurances of compliance with the requirements and recommendations of the EPA guidelines (40 CFR 241 Appendix III).

3–1.7 *Monitoring.* A plan must be developed and implemented to provide for adequate monitoring for each sanitary landfill accepting sludge. This plan must be specifically designed for applicable local conditions, and is to include:

a. Groundwater observation wells tested for heavy metals, persistent organics, pathogens, and nitrates;

b. where the surface water could be affected by direct runoff or leachate from the

sludge landfill, surface water monitoring tested for chemical oxygen demand and total dissolved solids. Additional testing may be necessary if it is determined that leachate is entering surface waters.

3-2. *Incineration.*

3-2.1 *General.* Sludge incineration and disposal of the resulting ash is an environmentally acceptable method for the disposal of sludge when the environmental assessment shows it to be appropriate. Incineration alone is a volume reduction method rather than ultimate disposal. After incineration ash, either dry or in scrubber water, remains to be disposed of to the land. Ash disposal must be designed to protect groundwater, to prevent dust, and to ensure no erosion to surface waters.

3-2.2 *Industrial Wastewaters.* When introduced into a municipal wastewater treatment works that practices sludge incineration, industrial wastewaters must be pretreated to reduce to a minimum the amounts of heavy metals and radioactive materials. In developing pretreatment programs, special attention must be given to the disposal of sludge created or materials removed during the pretreatment process. Disposal of these materials must be in an environmentally sound manner.

3-2.3 *Air Quality.* The emissions from the sludge incinerator must not result in violation of ambient air quality standards being exceeded and must meet the EPA air pollution emission standards of performance contained in the New Source Performance Standards for Sludge Incinerators (40 CFR 60.15, Appendix IV). These emission limits are based on a venturi scrubber, but any similar equipment which meets the standard is acceptable. Sludge incineration is known to vaporize any mercury present in the incoming sludge. EPA has published Amendments to National Emission Standards which would limit mercury emissions from the incineration and drying of wastewater treatment plant sludges to a maximum of 3200 grams per day (40 CFR 61.5, Appendix V).

3-2.4 *Specific Emissions.* Tests have shown that sludge incinerator emissions can contain volatilized mercury as well as persistent organic compounds, such as polychlorinated biphenyls, and particulates containing trace amounts of metals such as lead and cadmium. The effect of these compounds which are emitted from the incinerator must be assessed and the sludge should be assessed and the sludge should be tested to determine the quantities of compounds present. If the PCB's exceed 25 mg/kg dry sludge, then special measures should be taken to ensure at least 95 percent destruction of the persistent organic compounds in incineration. This could consist of testing the performance of an incinerator design to verify satisfactory performance or making allowances in the design. Increased temperature and residence time increase the assurance of destruction. Work with substantially pure PCB's (not sludges) showed essentially complete destruction at an operational temperature of 1600°F and residence time at that temperature of one second.

3-2.5 *Monitoring.* A plan must be developed and implemented to provide for adequate monitoring of each sludge incinerator. The stack gas emissions from sludge incinerators must be monitored to ensure compliance with 40 CFR 60.15 (Appendix IV). In addition, mercury, either in the sludge or in stack gas emissions, must be periodically tested to demonstrate compliance with 40 CFR 61.5 (Appendix V). Wastewater from industrial users must be monitored if it is determined that such users will be a significant source of mercury in the municipal sludge. Additional monitoring for organic pesticides, PCB's or heavy metals other than mercury, may be necessary for specific projects.

3-3. *Ocean Disposal.*

3-3.1 *General.* Ocean disposal of sewage sludge would be acceptable for treatment works presently using this method only when the sludge meets the criteria specified in 40 CFR 227 (Appendix IV) and when this disposal method is supported by the environmental assessment. The Federal Water Pollution Control Act as amended (PL 92-500), and the Marine Protection, Research and Sanctuaries Act of 1972 (PL 92-532) have established a Federal program of marine pollution abatement and control. EPA has issued regulations and criteria (40 CFR 220-227, Appendix IV) to govern the disposal of wastes to the marine environment. EPA controls such disposal by a system of permits for the discharge, transportation, and dumping of all waste materials into the marine environment, except for dredged material which is controlled by the Corps of Engineers, subject to EPA Criteria. Ocean discharge of sludge through outfalls is regulated by EPA under the National Pollutant Discharge Elimination System (NPDES).

3-3.2 *Permits.* Information available to EPA from permit applications to date indicates that those sludges currently being dumped exceed the criteria and are therefore being dumped under interim permits. One of the conditions of these interim permits is the requirement for an implementation plan to either reduce the toxicity of the materials to meet the criteria or find an alternative method of disposal. Interim permits are granted for one year only and the issuance of new interim permits is based on the progress demonstrated by the permittee on this implementation plan.

3-3.3 *Dumping Sites.* Ocean disposal of sewage sludge is strictly controlled by EPA. Currently EPA will approve only existing dumping sites presently in use for the disposal of particular kinds of waste, unless there is extremely strong evidence in favor of approval of a new location.

APPENDIX II—GROUND WATER EXTRACT FROM ALTERNATIVE WASTE MANAGEMENT TECHNIQUES FOR BEST PRACTICABLE WASTE TREATMENT EPA-40/9-75-013, OCTOBER 1975

over; the House Committee did urge that the information EPA publishes on alternative waste management techniques emphasize land disposal. Finally under Section 201, the House stressed that any determination of BPWTT should consider possible trade-offs between air, land, and water disposal of pollutants.

### C. Synopsis

The information contained in this document will guide policy-owned treatment works in selecting waste treatment alternatives to restore and maintain the integrity of the Nation's waters.

Chapter II specifies the criteria to meet best practicable waste treatment for the broad categories of treatment and discharge into navigable waters, land application and utilization practices, and reuse of treated wastewater. Criteria less stringent than those established in Chapter II are not acceptable. Criteria which are more stringent must be justified or be pursuant to more stringent State and local law.

Chapters III, IV, and V develop the rationale behind the criteria as well as present information pertaining to acceptable alternative waste management techniques. These chapters are not intended to include all possible approaches that are or might become practicable. Therefore, techniques and technologies not discussed in this document can be employed to achieve the criteria in the most cost-effective manner.

## CHAPTER II:
## CRITERIA FOR BEST PRACTICABLE WASTE TREATMENT

Applicants for construction grant funds authorized by Section 201 of the Act must have evaluated alternative waste treatment management techniques and selected the technique which will provide for the application of best practicable waste treatment technology. Alternatives must be considered in three broad categories treatment and discharge into navigable waters, land application and utilization practices, and reuse of treated wastewater. An alternative is "best practicable" if it is determined to be cost-effective in accordance with the procedures set forth in 40 CFR Part 35 (Appendix B to this document) and if it will meet the criteria set forth below.

### (A) Alternatives Employing Treatment and Discharge into Navigable Waters

Publicly-owned treatment works employing treatment and discharge into navigable waters shall, as a minimum, achieve the degree of treatment attainable by the application of secondary treatment as defined in 40 CFR 133 (Appendix C). Requirements for additional treatment, or alternate management techniques, will depend on several factors, including availability of cost-effective technology, cost and the specific characteristics of the affected receiving water body.

### (B) Alternatives Employing Land Application Techniques and Land Utilization Practices

Publicly-owned treatment works employing land application techniques and land utilization practices which result in a discharge to navigable waters shall meet the criteria for treatment and discharge under Paragraph (A) above.

The ground water resulting from the land application of wastewater, including the affected native groundwater, shall meet the following criteria:

*Case I:* The ground water can potentially be used for drinking water supply.

(1) The standards for chemical quality and pesticides specified in the EPA Manual for Evaluating Public Drinking Water Supplies (Appendix D) for drinking water supply sources should not be exceeded except as indicated below (See Note 1).

(2) If the existing concentration of a parameter exceeds the standards for chemical quality or pesticides, there should not be an increase in the concentration of that parameter due to land application of wastewater.

*Case II:* The ground water is used for drinking water supply.

(1) The criteria for Case I should be met.

(2) The bacteriological standards for drink-

ing water supply sources specified in the EPA Manual for Evaluating Drinking Water Supplies (Appendix D) should not be exceeded (See Note 1).

*Case III:* Uses other than drinking water supply.

(1) Ground water criteria should be established by the Regional Administrator based on the present or potential use of the ground water.

The Regional Administrator in conjunction with the appropriate State officials and the grantee shall determine on a site-by-site basis the areas in the vicinity of a specific land application site where the criteria in Case I, II, and III shall apply. Specifically determined shall be the monitoring requirements appropriate for the project site. This determination shall be made with the objective of protecting the ground water for use as a drinking water supply and/or other designated uses as appropriate and preventing irrevocable damage to ground water. Requirements shall include provisions for monitoring the effect on the native ground water.

**(C) Alternatives Employing Reuse**

The total quantity of any pollutant in the effluent from a reuse project which is directly attributable to the effluent from a publicly-owned treatment works shall not exceed that which would have been allowed under Paragraphs (A) and (B) above.

**NOTE 1**

Any chemical, pesticides, or bacteriological standards for drinking water supply sources hereafter issued by EPA shall automatically apply in lieu of the standards in the EPA Manual for Evaluating Public Drinking Water Supplies.

## CHAPTER III:
## WASTE MANAGEMENT TECHNIQUES INVOLVING LAND APPLICATION OR LAND UTILIZATION

Land application systems can be classified with respect to the ultimate disposition of the applied wastewater: (1) percolation of wastewater through the soil until it becomes part of the permanent aquifer and (2) collection of land applied wastewater either by means of underdrain systems or as a result of surface runoff. Percolation systems which result in permanent ground water must meet the ground water quality criteria established for such systems. Land application systems which collect the applied wastewater in underdrain systems and/or result in surface runoff must comply with the wastewater treatment and discharge criteria if the collected wastewater is discharged to navigable waters.

Three different cases can be identified for percolation of wastewater through the soil: (1) the receiving ground water has the potential for use as a drinking water supply; (2) the receiving ground water is used as a drinking water supply; and (3) the receiving ground water has other uses. Achieving best practicable technology for these cases requires meeting the applicable ground water criteria. The specific ground water criteria are determined on the basis of the level of ground water protection necessary.

Where the receiving ground water has the potential to be used as a drinking water supply, the bacteriological criteria for drinking water supplies (Appendix D) can be met by standard water treatment practice at a reasonable cost. However, because the water treatment technology available for the removal of chemical pollutants and pesticides is not widely practiced and is costly, the chemical and pesticide criteria (Appendix D) should apply when land application is considered.

In the case of receiving ground water which is already being used as a public or private water supply, protection of the ground water from pathogenic pollution is necessary in addition to meeting chemical and pesticides criteria. The bacteriological criteria in this case should be consistent with the level of treatment received by the ground water prior to public use. If, for example, a number of existing private wells use the ground water resulting from the land application system, the bacteriological standards for ground water usable without treatment shall apply.

When the ground water is not being used as a water supply because of contamination and does not have the potential through treatment to be used as a drinking water supply, the Regional Administrator will determine the applicable ground water criteria on a case-by-case basis. In making these determinations, the Regional Administrator will consider localized conditions as well as the future intended uses of the ground water.

For all of the above categories, if the existing

# APPENDIX D

## GROUND WATER REQUIREMENTS

**Water Treatment Requirements***

*1. General Requirements*

The water quality requirements of the EPA Drinking Water Standards are minimum requirements, and good quality water should have physical and chemical characteristics considerably better than the limiting values established in the EPA Drinking Water Standards (Sections 4.2, 5.1, 5.2, 6.1, and 6.2). For example, water with turbidity of 5 units and a color of 15 units may be acceptable, but in a coagulated, filtered water such values could indicate serious malfunctioning of the purification process. (The EPA Drinking Water Standards are being revised currently, and will contain a recommendation that the turbidity standard be reduced to 1 turbidity unit. This and other revisions of the Drinking Water Standards, proposed at the time of this printing, are shown on the following pages.) Similarly, increased concentrations of copper and iron could indicate a corrosiveness that would be objectionable to consumers, even though the concentrations of the metals did not exceed recommended limits. In well water an increase in chlorides over the normal amount found in ground waters in the area may be the first indication of pollution.

The type of treatment required depends on the characteristics of the watershed, the raw water quality, and the desired finished water quality. If pollution of the source water is increasing, plant facilities, which were adequate for treatment of a nonpolluted water, may become inadequate. The production of water that is free from pathogenic organisms, aesthetically satisfactory to the senses, and reasonably acceptable chemically becomes increasingly difficult when the raw water has a high and varying chlorine demand, contains large numbers of coliform bacteria, or contains high concentrations of dissolved solids, toxic substances, or taste and odor producing substances.

When evaluating the ability of a water supply system to constantly produce a safe and satisfactory water, these factors should be considered:

(a) the quality of water produced at times of unusual stress, such as during heavy run-offs, periods of drought, or periods of excessive demand as shown in the records;

(b) the quality of the raw and finished waters, as determined by laboratory data and sanitary surveys, and any trends in improvement or deterioration;

(c) the purification processes, including the facilities used to apply disinfectants at various locations in the treatment process, and their capacities compared with the capacities considered necessary to meet maximum anticipated requirements;

(d) the treatment processes used and their reliability in changing raw water characteristics to produce a finished water that continuously meets the PHS Drinking Water Standards;

(e) the minimum residual chlorine concentration in the plant effluent water, when chlorine is used, together with the time that this or greater chlorine levels were maintained;

(f) the qualifications of the operators and laboratory personnel, as indicated by appropriate training, or certification, or both; and

*"Manual For Evaluating Public Drinking Water Supplies" U.S. Environmental Protection Agency, 1971, pp. 4-12; updated with Proposed Primary Drinking Water Regulations, June 1975.

(g) the laboratory facilities and analytical procedures, frequency and extent of their use, and application of the data to operational control.

*2. Extent of Treatment*

The Public Health Service recommends that all municipal water supplies, whether they be ground water or surface water, receive treatment by disinfection regardless of the quality of the water. The benefits from the added protection provided by disinfection far outweigh the increased cost and the added maintenance incurred by the water utility. When coliform density is used as one criterion for judging treatment requirements, raw waters can be divided into three groups: clean, clear, and polluted waters. The coliform densities of the raw waters can be expressed in terms of the most probable number (MPN) from the multiple-tube fermentation technique, or actual coliform counts determined by the membrane filter (MF) technique.

The requirements are given for three groups of water: those usable without treatment, those needing disinfection only, and those needing complete treatment. The quality requirements listed below are the proposed EPA primary drinking water standards*, that are proposed as revisions to the current PHS Drinking Water Standards. They differ from the current PHS Standards in that some standards have been added, some have been deleted, and others modified.**

Group I. Requirements for Water Usable Without Treatment

A. *Bacteriological Quality:* The coliform standard remains the same as the PHS Drinking Water Standards, 1962, plus the inclusion of a standard plate count limit of 500 organisms per ml.

B. *Physical Quality:* should meet the following standards.

| | |
|---|---|
| Turbidity | 1 turbidity unit (up to 5 TU may be allowed in some cases) |

*Proposed Interim Primary Drinking Water Regulation, March 14, 1975

**The EPA is also considering secondary drinking water regulations pertaining to color, taste and odor, chloride, copper, foaming agents, iron, manganese, sulfate and zinc. Ground water requirements for land application systems should consider these parameters in terms of aesthetic acceptability of existing and potential drinking water supplies and the cost-effectiveness of control by standard water treatment practice.

C. *Chemical Quality:* chemical concentrations should not exceed the following:

| Substance | Maximum Allowable Limits concentration mg/liter |
|---|---|
| Arsenic (As) | 0.05 |
| Barium (Ba) | 1 |
| Cadmium (Cd) | 0.010 |
| Chromium (Cr) | 0.05 |
| Cyanide (CN) | 0.2 |
| Flouride (F) [a] | |
| up to 53.7°F | 2.4 |
| 53.8-58.3 | 2.2 |
| 58.4-63.8 | 2.0 |
| 63.9-70.6 | 1.8 |
| 70.7-79.2 | 1.6 |
| 79.3-90.5 | 1.4 |
| Lead (Pb) | 0.05 |
| Mercury (Hg) | 0.002 |
| Nitrate Nitrogen | 10 |
| Organics-Carbon Absorbable CCE | 0.7 |
| Selenium (Se) | 0.01 |
| Silver (Ag) | 0.05 |

[a] Annual average of maximum daily air temperature.

Substances not included in the above table that may have deleterious physiological effect or that may be excessively corrosive to the water supply system should not be permitted in the raw water supply.

D. Radioactivity: should comply with the following limits:

RADIUM 226, RADIUM 228, and GROSS ALPHA PARTICLE RADIOACTIVITY

Combined Radium 226 and Radium 228 - 5pCi/l
Gross Alpha Particle Activity - 15pCi/l

BETA PARTICLE and PHOTON RADIOACTIVITY from MAN-MADE RADIONUCLIDES

The average annual concentration of beta particle and photon radioactivity from man-made radionuclides shall not produce an annual dose equivalent to the total body or any internal organ greater than 4 millirem, assuming a 2 liter per day drinking water intake.

E. *Pesticides:* should not exceed the following limits:

| Pesticide | Maximum permissible concentration, mg/l |
|---|---|
| Chlordane | 0.003 |
| Endrin | 0.0002 |
| Heptachlor | 0.0001 |
| Heptachlor epoxide | 0.0001 |
| Lindane | 0.004 |
| Methoxychlor | 0.1 |
| Toxaphene | 0.005 |
| 2, 4-D | 0.1 |
| 2, 4, 5-TP | 0.01 |

Group II. Requirements for Water Needing Disinfection Only

A. *Physical, Chemical, Radioactivity, and Pesticide Requirements:* the requirements as shown for untreated raw ground water (Groups I.B, I.C, I.D, and I.E) should be met. If the water does not consistently meet all these requirements, consideration should be given to providing additional treatment during periodic decreases in quality that result from high turbidity, tastes, etc.

B. *Bacteriological Quality:*

1. Fecal Coliform Density: If fecal coliform density is measured, the total coliform density discussed below may be exceeded, but fecal coliform density should not, in any case, exceed 20 per 100 milliliters as measured by a monthly arithmetic mean. When the fecal coliform vs. total coliform criterion is used for Group II water, the fecal coliform count should never exceed the 20 per 100 milliliters monthly arithmetic mean. This fecal coliform standard only applies when it is being measured on a regular basis.

2. Total Coliform Density: Less than 100 per 100 milliliters as measured by a monthly arithmetic mean.

Group III. Requirements for Water Needing Treatment by Complete Conventional Means Including Coagulation, Sedimentation, Rapid Granular Filtration, and Disinfection (Pre and Post)

C. *Bacteriological Quality:*

1. Fecal Coliform Density: If fecal coliform density is measured, the total coliform density discussed below may be exceeded, but fecal coliform should not exceed 2,000 per 100 milliliters as measured by a monthly geometric mean.

2. Total Coliform Density: Less than 20,000 per 100 milliliters as measured by a monthly geometric mean.

The same rationale applies here as in the Group II waters concerning the use of the fecal coliform vs. total coliform criterion. In no case should the fecal coliform count exceed the 2,000 per 100 milliliters monthly geometric mean.

The arithmetic mean is used with the Group II waters because the bacteriological data from these waters will be of lesser magnitude than that from the Group III waters; this difference in magnitude between the monthly means of the Group II and Group III waters is best reflected by the arithmetic and geometric means, respectively.

These bacteriological limits may possibly be exceeded if treatment (in addition to coagulation, sedimentation, rapid granular filtration, and disinfection) is provided and is shown to be doing a satisfactory job of providing health protection.

B. *Physical Quality:* Elements of color, odor, and turbidity contribute significantly to the treatability and potability of the water.

1. Color: A limit of 75 color units should not be exceeded. This limit applies only to nonindustrial sources; industrial concentrations of color should be handled on a case-by-case basis and should not exceed levels that are treatable by complete conventional means.

2. Odor: A limit of 5 threshold numbers should not be exceeded.

3. Turbidity: The limits for turbidity are variable. Factors of nature, size, and electrical charge for the different particles causing turbidity require a variable limit. Turbidity should remain within a range that is readily treatable by complete conventional means. It should not overload the water treatment works, and it should not change rapidly either in nature or in concentration when such rapid shifts would upset normal treatment operations.

C. *Chemical Quality:* Since there is little reduction in chemical constituents with complete conventional treatment, raw water should meet the limits given for Group I.C.

D. *Radioactivity:* Should comply with Certification Limits given in Group I.D.

E. *Pesticides:* Should comply with requirements for pesticides as shown for untreated raw ground water in Group I.E.

Infectious material, the increasing diversity of chemical pollutants found in Group III raw waters, and the many different situations encountered in regional and local problems make it impractical to prescribe a limited selection of facilities and processes that can effectively handle all problems presented by raw water and its sources. Future improvements in treatment technology cannot be reasonably assisted or regulated by requiring the fixed process steps considered good for today's technology. Table 1 describes some factors that increase the difficulty in securing disinfection, e.g., adequate disinfection with halogens depends on temperature, pH, contact time, and concentration of disinfectant.

Types of disinfection other than chlorination must be demonstrated to function effectively in all compositions of water likely to be encountered from the source used. If a distribution system is of any considerably length, the disinfection method should provide a residual protection that can be easily measured.

Table 1. CONDITIONS CREATING DIFFICULTIES AT THE WATER PLANT AND IN THE WATER MAINS

| Bacterial and biological conditions | Chemical conditions | Physical and operational conditions |
|---|---|---|
| Increasing numbers of coliforms | Ammonia nitrogen | Low temperature |
| Biological pollution, i.e., algal or fungal metabolic products that effect chlorine demand | Toxic materials or taste and odor requiring removal | Extended distribution systems |
| Filter clogging organisms that effect chlorine demand | Color or organic dispersing agents (anticoagulants), lignin compounds | Highly variable water quality |
| | Chlorine demand | Rapid variation in flow and turbidity of surface water resource |
| | Iron and manganese | |
| | High organic content | Tidal effects |
| | High or organic content | |
| | High or fluctuating pH | |

Where water sources show continuing quality deterioration or the quality of water available is not adequate for future demand, the water purveyor should be examining alternate or auxiliary sources of supply and should have positive plans to procure adequate facilities and sources.

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